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Working paper
on
an inspection method for verifying
the status of shutdown plutonium production reactors

I. Introduction

This paper describes technical aspects of one possible method of determining that reactors for the production of plutonium that are shutdown in compliance with an arms control of disarmament agreement have remained so between visits of inspectors. This method is presented as an example and is intended to encourage discussion of this and other possible methods for such verification.

II. Description of the technique

The shutdown monitoring system basically includes four simple concepts:

1. Target material placed in a reactor case will become radioactive in the event of reactor operation.

2. A wire or tape fixes the position of the target material within the reactor so as to be subject to the reactor's neutron flux, if any.

3. The tape is so fabricated that it is unique and hence any substitution of the tape can be detected.

4. An exterior seal at each end of the channel provides the inspection team assurance that the wire or tape will have remained in its fixed position between inspections.

In the system, the target material, e.g. cobalt, is contained within the wire or tape. The latter is designed to reveal any attempt to break and rejoin it. Special fittings have been designed to enhance the integrity of the juncture of the safing band and the exterior seal(s).

An international inspection team of two professional-level and two technician-level specialists can install the system without damage to the reactor given about one

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week's access to the operating face(s) of the reactor. Return inspections, spaced several months apart and involving checking of seals and replacement of some of the monitor-tapes, can be carried out in one or two days.

The target material will be activated approximately linearly with exposure to neutrons. The radioactivity, if any, can be read with standard radiation detection meters.

The in-reactor safing bands establish a known fixed location for the neutron detector material within the reactor core. To insure that removal would be detected, any attempt to repair a break or cut in the band must be discernible to the inspection team.

The primary device developed for this purpose is a bimetallic wire formed by the co-extrusion of a jacket material over a lower-melting-point core material. The latter is introduced in wire form together with small quantities of other materials in finer wires. The materials used are natural cobalt for neutron sensitivity and tungsten for X-ray opaqueness. The co-extruded wire is flattened to a tape a few millimeters thick. An X-ray pattern of the random orientation of the fine tungsten strands within the band produces a "fingerprint". The different melting points of the core and the jacket of the bimetallic band will cause flaws to be introduced if repair of cuts is attempted.

The function of the exterior seals is to provide assurance that the safing band could not be removed in its entirety without costly disassembly of the reactor itself. A proper choice of location for installing the safing tape can maximize the effort that would be required to disassemble the reactor core.

The concept employed is that of enclosing randomly oriented metallic particles in the exterior seals in a three dimensional form not subject to reproduction. A seal is formed by mixing the powder and catalyst of a commercially available epoxy resin. The syrupy translucent material is then formed around metal turnings and other random particles. The "fingerprint" of the epoxy seal is recorded by photography and radiography from two or more aspects. Before- and after- photographs and radiographs are compared to determine that the seal has not been tampered with.

The Host Nation would provide a liner tube of reasonably noncorrosive metal extending completely through the reactor core and protruding a few centimeters beyond the exterior hardware of both process faces. This provides protection to the reactor and facilitates installation of safing bands, seals, and a flat safing plate "washer" at each end of the tube. The washer covers the area of the surrounding lattice positions radially in each direction and protects the reactor face as well as provides an orientation base for the seal and subsequent photographs and radiographs of it.

Other variations of safing bands and seals are feasible and worthy of consideration as are quite different verification techniques. It is believed, however, that the techniques described can serve as an adequate example of a solution to the problem of verification of shutdown production reactors.

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